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THE ORIGIN OF VERTEBRATES.

The Origin of Vertebrates. By Dr. Walter Holbrook Gaskell, F.R.S. Pp. iv+537; 168 figures. (London: Longmans, Green and Co., 1908.) Price 21*s.* net.

TWENTY years ago the author of this interesting book was led by his studies on the innervation of the heart to make a comparison between the central nervous system in vertebrates and that in appendiculate invertebrates. This led him to a highly original theory of the derivation of vertebrates from an arthropod stock, and the researches of twenty years have strengthened his confidence in this conclusion. Encouraged by what Huxley wrote to him in 1889, "There is nothing so useful in science as one of those earthquake hypotheses, which oblige one to face the possibility that the solidest-looking structures may collapse," Dr. Gaskell has published paper after paper in support of the view that the infundibulum may represent the old œsophagus, the ventricles of the brain the old cephalic stomach, the canal of the spinal cord the long straight intestine, the cranial segmental nerves the infra-œsophageal ganglia, the cerebral hemispheres and optic and olfactory nerves the supra-œsophageal ganglia, and the spinal cord the ventral chain of ganglia.

"Not having been educated in a morphological laboratory and taught that the one organ which is homologous throughout the animal kingdom is the gut, and that therefore the gut of the invertebrate ancestor must continue as the gut of the vertebrate, the conception that the central nervous system has grown round and enclosed the original ancestral gut, and that the vertebrate has formed a new gut, did not seem to me so impossible as to prevent my taking it as a working hypothesis, and seeing to what it would lead."

As is well known, there are various rival theories as to the origin of vertebrates, though the prevalent position is agnostic. Thus an attempt has been made to derive vertebrates from annelids by supposing a reversal of surfaces, but the author regards the difficulties of this hypothesis as "insuperable." On another view the annulate and the vertebrate types had a separate origin; in the former, the digestive tube pierced the central nervous system and was situated dorsally to its main mass; in the latter, the segmented central nervous system was situated from the first dorsally to the alimentary canal, and was not pierced by it. According to Gaskell, this theory does not explain the tubular appearance of the central nervous system. This, which seems to some an unimportant architectural consequence of the mode of development from a medullary groove, is to Gaskell a recapitulation of the way the nerve cord grew round the old gut. Gaskell also says that the extraordinary resemblance between the structure and arrangement of the central nervous systems of vertebrates and arthropods is against the view of their phyletic distinctness. But, given segmentation in two distinct types, we naturally expect similarity in the general plan of innervation.

Dr. Gaskell thinks that the nervous system furnishes the most important clues to relationship, and arthropods alone possess a central nervous system closely comparable with that of vertebrates. "The vertebrate tissues resemble more closely those of the arthropod than of any other invertebrate group." Argument from analogy "compels one to the conclusion that the fishes arose from the race which was dominant at the time when the fishes first appeared," i.e. from the Palæostraca. And do not the ancient fishes, like Pteraspis, Cephalaspis, and Pterichthys, resemble in a remarkable manner members of the Palæostracan group, "so that again and again palæontologists have found great difficulty in determining whether a fossil is a fish or an arthropod"? Thus various lines of argument indicate the origin of vertebrates from arthropods, or, more precisely, that the vertebrate was formed from the Palæostracan without any reversal of surfaces, but by the amalgamation of the central nervous system and the alimentary canal. The vertebrate's cerebral hemispheres and basal ganglia correspond to the supra-œsophageal ganglia of the arthropod, the crura cerebri to the œsophageal commissures, the infra-infundibular part of the brain to the sub-œsophageal ganglia, the infundibular tube to the œsophagus, the third ventricle to the cephalic stomach, the canal of the spinal cord to the intestine. The vertebrate's gut is, of course, a new formation "necessitated by the urgency of the case." Its homology with the invertebrate gut is a morphological illusion. It is only an analogue.

All sorts of difficulties rise in the mind as one considers this hypothesis, but the author is nothing if not ingenious in meeting them. Our old clues—through lancelets, tunicates, and enteropneusts—are brushed aside, and the ammocœte—so peculiar in many ways—is trusted to as the lowest perfect vertebrate. The highly specialised character of Limulus and the Palæostraca would deter many from looking to them as even near probable originators; but this is not the author's view. If the infundibular tube be "œsophagus," the third ventricle "cephalic stomach," the spinal canal "intestine," and the neurenteric canal the old way to the anus, we land in difficulties which seem to us as insuperable as those of the reversal hypothesis seem to the author. We want to know, for instance, where the arthropod's mesenteron has gone. But this is only one of the most obvious difficulties, and it is no difficulty to the author, who throws the germ-layer theory overboard as a morphological anachronism, a survival of a dogma due to the lively imagination of Haeckel.

In his second chapter Dr. Gaskell finds support for his thesis in the eyes. The pineal gland represents a pair of median eyes; Ostracoderms had median as well as lateral eyes; so has the king-crab, and so had Eurypterids. The inverted retinas of the vertebrate lateral eyes find their counterpart in the lateral eyes of arachnids, and the Palæostraca were ancestral to both. But do not the vertebrate lateral

eyes develop characteristically in the most intimate connection with optic diverticula from the neural tube? Dr. Gaskell meets this objection by insisting that the retina and optic nerve were originally outside a non-nervous tube—an anterior diverticulum on each side from the alimentary canal—and he remarks :—

"It is again a striking coincidence to find that Artemia, which with Branchipus represents a group of living crustaceans most nearly related to the trilobites, does possess two anterior diverticula of the gut which are in extraordinarily close relationship with the optic ganglia of the retina of the lateral eyes on each side."

We are accustomed to think of arthropods as typically provided with a chitinous exoskeleton, and thus contrasted with vertebrates, which have an internal skeleton of cartilage or bone. But Dr. Gaskell shows that this difficulty "vanishes into thin air" before the discovery of the branchial cartilaginous bars of Limulus, together with that of the internal prosomatic plastron. He quotes Schmiedeberg, who pointed out that glycosamine is a bridge between chitin and chondrin. The Palæostraca were the dominant arthropod race when vertebrates first appeared, and "not only had they manufactured an internal cartilaginous skeleton, but they had got it both in structure and position, exactly at the stage at which the vertebrate skeleton starts." This almost sounds like proving too much, yet it does not account for the vertebrate's dorsal axis.

Morphologists are accustomed to lay some emphasis on the branchial clefts of vertebrates, but Dr. Gaskell thinks of the branchial unit as a gill-bearing appendage, and does not hesitate to describe in ammocœtes a respiratory chamber into which a symmetrical series of sunk-in branchial appendages, the so-called diaphragms, are dependent. Two large longitudinal venous sinuses in Limulus correspond to the two veins which come together to form the heart and ventral aorta of the vertebrate. Morphological dogmatism is startled by the homology between the breathing organs in king-crab and lamprey, but it is shocked by the derivation of the thyroid gland from the palæostracan uterus—a derivation the violence of which, as it seems to us, is not lessened by the light it sheds on the mysterious physiological nexus between the sexual organs and the thyroid in man and other animals. The nasal tube of ammocœtes corresponds to the olfactory tube of a scorpion-like animal, and the pituitary body shows by similarity of structure, as well as of position, that it arose from the coxal glands, which were situated at the base of the four endognaths. Special sense-organs, such as are found in the flabellum of Limulus and in the pectens of scorpions, may be looked upon as giving origin to the vertebrate auditory apparatus. Even more surprising than these conclusions is the ingenuity of the evidence that the author uses in support of them.

We cannot follow Dr. Gaskell in his detailed comparison of segments, nerves, and musculature in vertebrates and arthropods, but we must direct attention to the twelfth chapter, where the difficulties suggested by the characteristic segmental excretory organs of vertebrates and by the state of the cœlom in arthropods are dealt with. The author shifts off from the Palæostraca to the hypothetical Protostraca —ancestral to both arachnids and crustaceans—which possessed in every segment a pair of appendages and a pair of cœlomic cavities, each with excretory organs or coxal glands. The hypothetical Protostraca arose from the polychætes. As to the notochord and the vertebrate gut, the author starts from a trilobite-like animal with a deep ventral groove and pleural fringes; the groove becomes a tube, and sinks in as the notochord; a continuation of the same process of ventral groove-formation, combined with the obliteration of appendages and the growth of pleural folds, leads to the closed vertebrate gut. All seems consistent with an earthquake-hypothesis.

In his extremely interesting fourteenth chapter, Dr. Gaskell shows that the development of a vertebrate, *e.g.* as regards nerve-tube, branchial skeleton, cranial segments, and excretory organs, reads like a recapitulation of the steps which led long ago from arthropod to vertebrate. He also expounds the suggestive view that a very much more important embryological idea than that of the three germinal layers is that which centres the metazoan body in the nervous system, and not in the gut. In the body there are master-tissues —all the neuro-muscular and neuro-epithelial structures—and within the meshes of these there are germ-cells, blood-corpuscles, lymph-corpuscles, connective-tissue cells, &c., living a symbiotic existence independent of the central nervous system.

The author regrets that his previous publications bearing on the palæostracan origin of vertebrates have not been adequately criticised. We suppose that this is because the author pays no heed to the conventional canons of morphological work. We may say that the known Palæostraca are much too highly specialised animals to be regarded as plausible starting-points for a new phylum, but the author does not share this view. We may say that the ammocœte is a very peculiar larval chordate type, likely to mislead, and that it is quite illegitimate to ignore the hints offered by Amphioxus and the tunicates; but the author does not agree. The author makes out a seemingly strong case by showing extraordinary and unsuspected resemblances between ammocœte and king-crab, and there is no use criticising these in a general way. The supposed homology of the branchial cartilaginous bars in king-crab and in ammocœte—to take one instance—must be examined in detail by an unprejudiced expert. We wish simply to point out that the ingenious author flits a little from type to type; arachnids are called in where crustaceans will not help; Peripatus is summoned when the Palæostraca prove broken reeds; and, after all, the author takes refuge in the hypothetical Protostraca, which have a good deal of the annelid about them. We do not think that the author gets over the difficulties presented by the vertebrate's gill-slits, notochord, cœlom, ventral heart, and so on, but we agree that there are difficulties in face of every attempt to affiliate vertebrates to an invertebrate stock. The question is as to which theory presents least difficulty

if, indeed, any theory is legitimate. As we have already indicated, we are of opinion that Dr. Gaskell's theory is fatally condemned because, as he says, it makes the assertion that what was hypoblast in the arthropod has become epiblast in the vertebrate, and what was epiblast in the arthropod has become hypoblast in the vertebrate. But Dr. Gaskell thinks that the germ-layer theory argues in a vicious circle, and he practically throws it overboard—which we are not prepared to do. Yet this makes criticism very difficult.

No one can read this book without being impressed with the author's audacious ingenuity, with his patient following up of clues into remote recesses, and with the good humour with which he holds his *unus contra mundum* position. Whether he is right or wrong, he has written an entertaining book and found out a lot of interesting things by the way. We cannot pass from the book without feeling the precariousness of pedigree-construction and the need for some re-statement of the principles of morphology. Perhaps we should also recall the fact that if it be impossible to attach the vertebrate phylum with even plausibility to annelid or arthropod or any other stock, a more modest inquiry remains—How, from what we know of invertebrates, can we conceive of the origin of the various characteristic vertebrate features? To this inquiry, which seems to us more promising and profitable than the search for a lost pedigree, we think that this fascinating book has made several noteworthy contributions.

AN INSULAR FLORA.

Botany of the Faeröes. Based upon Danish Investigations. Published by the aid of the Carlsberg Fund. Vols. 1–3. Pp. xxviii + 1070; illustrated with 24 plates and 202 figures in the text. (Copenhagen and Christiania: Glydendalske Boghandel, Nordisk Forlag; London: John Wheldon and Co., 1901–1908.)

ANY addition to our knowledge of the natural history of the islands on the north-west fringe of Europe must be welcome. Most people know little more of one such group—Faeröe Islands—than that they are somewhere in the North Atlantic There are eighteen islands in all, lying, mostly more or less befogged, in 62° N. lat. and 70° W. long., at the meeting point of a warm Atlantic current with a cold polar one from the east coast of Iceland. They are nearer the Shetlands (300 kilos. distant) than Iceland (480 kilos. distant). They are all basaltic in origin. The basalt occurs in horizontal beds, contains 10 per cent. of lime, and weathers easily. There are 15,000 people and 100,000 sheep on them. Their mountains are 3000 feet in height, and are still unexplored for the most part. The average annual temperature is 6·5° C., the winter being mild, and summer cold, with rapid changes. There are 23 per cent. dry, 12 per cent. calm, and only 5 per cent. clear days in the year.

In the work before us, Prof. Warming and his Danish colleagues have given, within the limits of 1100 octavo pages, in an excellent English translation, with very few slips, a model survey of the flora of the islands, on the practical completion of which (begun in 1896) they are to be congratulated. Not the least valuable feature in the publication is the large series of beautiful illustrations, some of which, reproduced on a larger scale in the "Vegetationsbilder" of Karsten and Schenk, are the best photographs of marine algæ the writer has seen.

The many contributions to the report do justice to the work of Lyngbye and other early investigators. After a short historical introduction by Warming, Ostenfeld devotes a hundred pages to the description of the geology and physical geography of the islands. We are reminded of the island of Heligoland, which, like the Faeröes, is being worn away on its west and north-west coasts by the sea, so that, in both cases, in the course of time the islands will disappear. In the case of the Faeröes subsidence is contributing to this result.

In a short review it is impossible to do more than mention the work of the various experts. In the lists of each group there are valuable notes accompanying many of the species, as well as general conclusions and comparisons with the distribution of the same group in Norway, Iceland, and Scotland. The comparison with the flora of the Shetlands, especially of the lower groups of plants, is vitiated by the incompleteness of the information available. In one case the Danish observer visited the Shetlands to collect the information needed for the comparison.

Broadly speaking, the conclusion on each group of plants studied is that the islands have such a flora as their geographical position would lead one to expect—a touch of the subarctic type found in Iceland and North Scandinavia, with, in the main, the temperate-European and Atlantic types. The hawkweeds (twenty-one species and two varieties) examined by H. Dahlstedt are all endemic; half of them are of the Atlantic type, and post-Glacial in origin. The vascular plants are dealt with by C. H. Ostenfeld, who, in vol. i., treats of their distribution, and in vol. iii. makes a valuable contribution to plant-ecology. This account has been also issued as a separate work, and includes an account of Raunkiaer's biological types, which are based on the selective adaptation of plants by bud protection to unfavourable climatic conditions. There are 298 vascular plants (flowering plants and ferns), and of these 90 per cent. are herbaceous perennials. There are no trees on the islands, and only fourteen species at all woody. Two of these are *Dryas octopetala* and *Salix herbacea*. The illustrations (*e.g.* that on p. 904, showing how the hapaxanthic *Cochlearia officinalis* becomes perennial) are excellent.

C. Jensen describes in his enumeration of the 391 forms of Bryophyta one new species, *Pohlia faeröensis*, and many new varieties. Sphagnum is well represented, and peat occurs on nearly every island. There is also some coal of inferior quality. The lichens, 220 species as listed by Branth, are generally stunted, due in part to competition with the mosses which thrive in the moist climate, and in part to the strong winds and the browsing sheep. E. Rostrup records